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Walter et al.

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[54] **FUEL INJECTOR WITH INNER CHAMBER VACUUM**

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[73] Assignee: **The Bendix Corporation**

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[51] **Int. Cl.**³ **F02B 3/00;** F02M 41/02

[52] **U.S. Cl.** **123/467;** 123/447

[58] **Field of Search** 123/446, 447, 449, 467, 123/516, 506; 239/89, 90, 91, 92, 533.5, 95; 417/462

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,372,272	2/1983	Walter et al.	123/467
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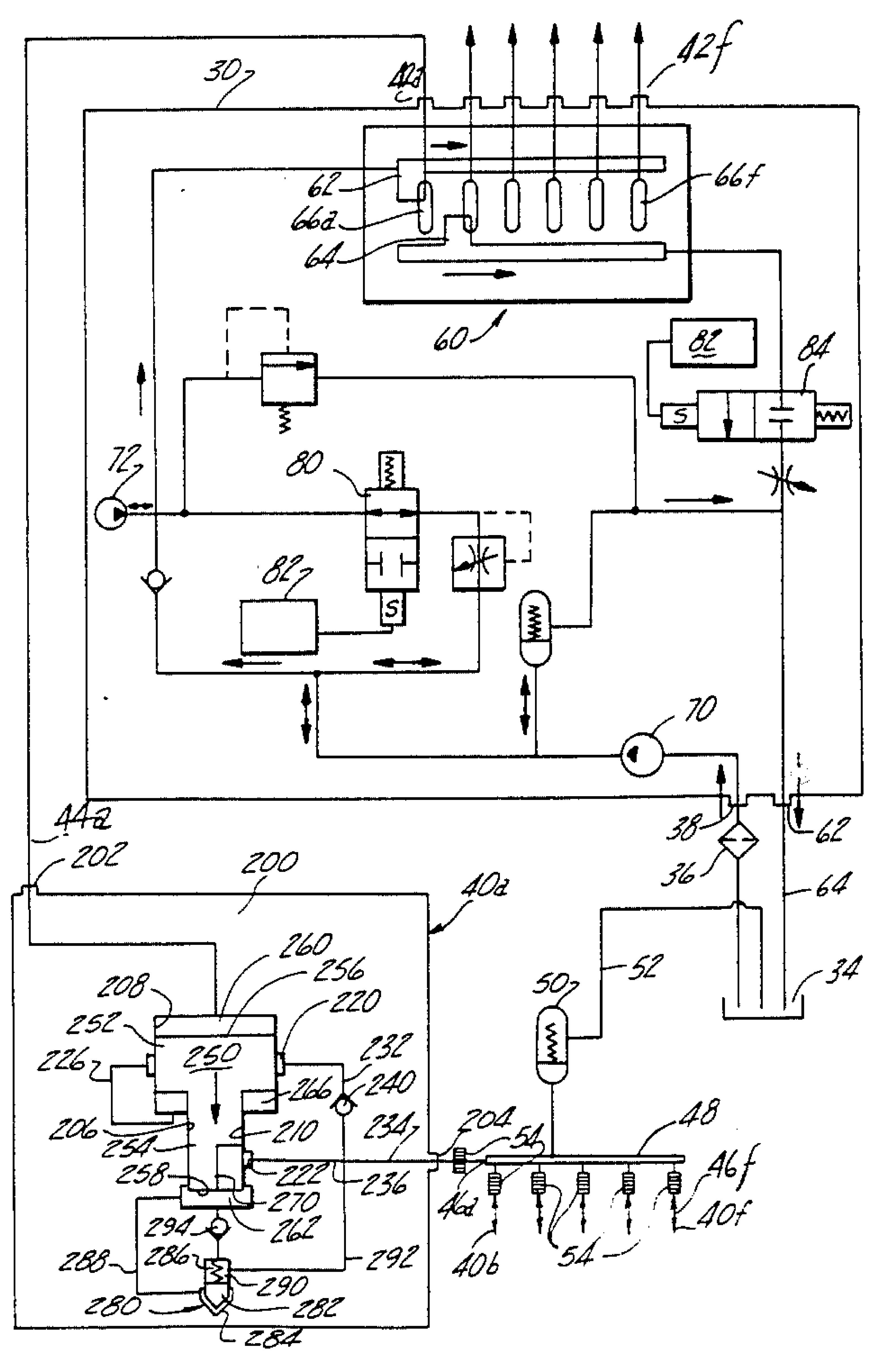
[57] **ABSTRACT**

A fuel system for a diesel engine incorporating a distributor pump for controlling the operation of a plurality of fuel injectors. Each injector comprising a housing having situated therein an intensifier piston. The housing and intensifier piston cooperate to create a plurality of variable volume chambers including an upper, middle and metering chamber. The fuel injector incorporates a means entrapping a quantity of fuel during the injection mode of operation means for forming a vacuum pressure within the middle chamber to reduce the trapped fuel to its vapor pressure after the metering mode of operation has begun to ensure that the actual pressure intensification is nearly equal to the theoretical intensification ratio by minimizing unnecessary losses.

20 Claims, 6 Drawing Figures



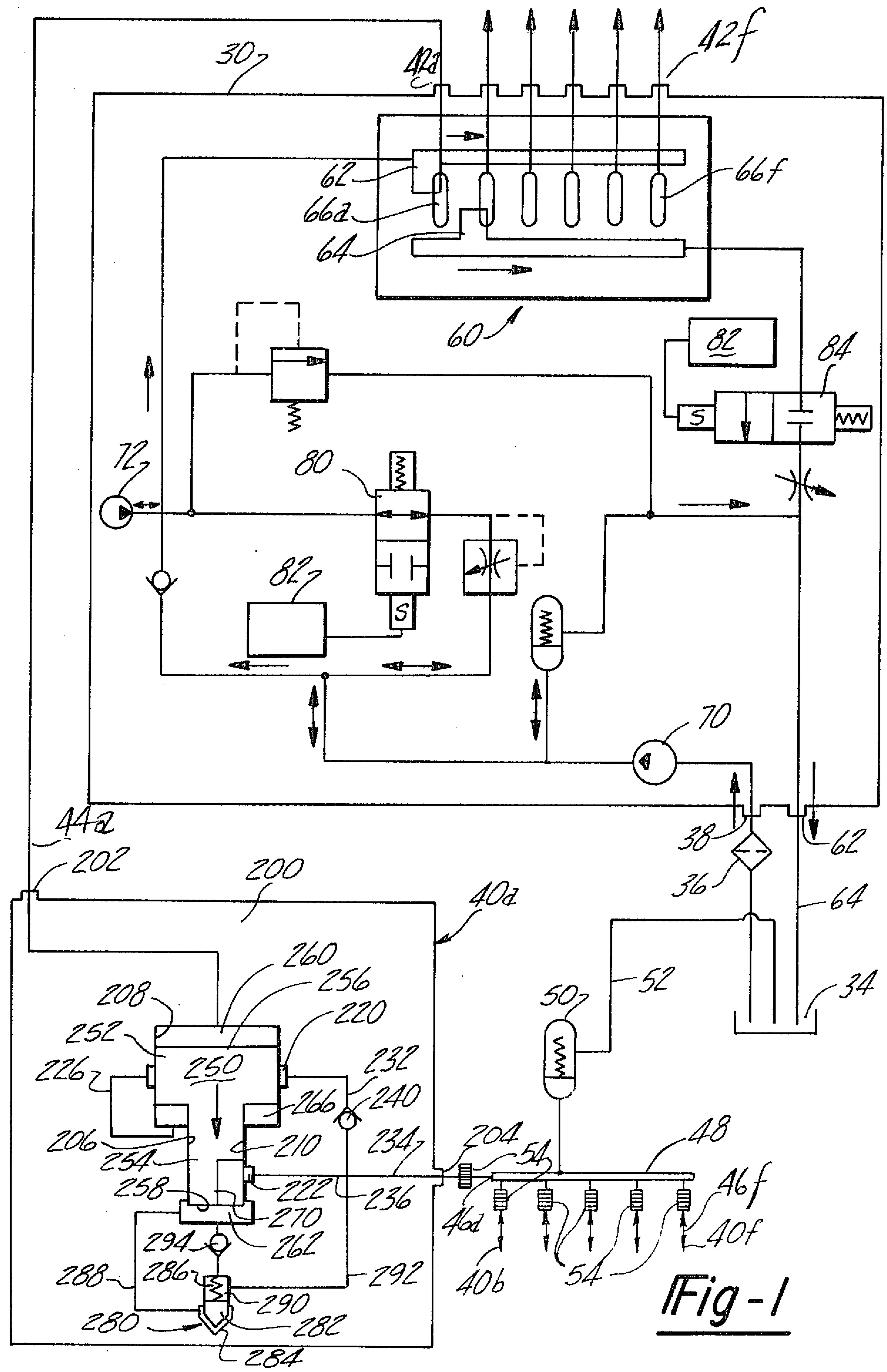

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Fig-1

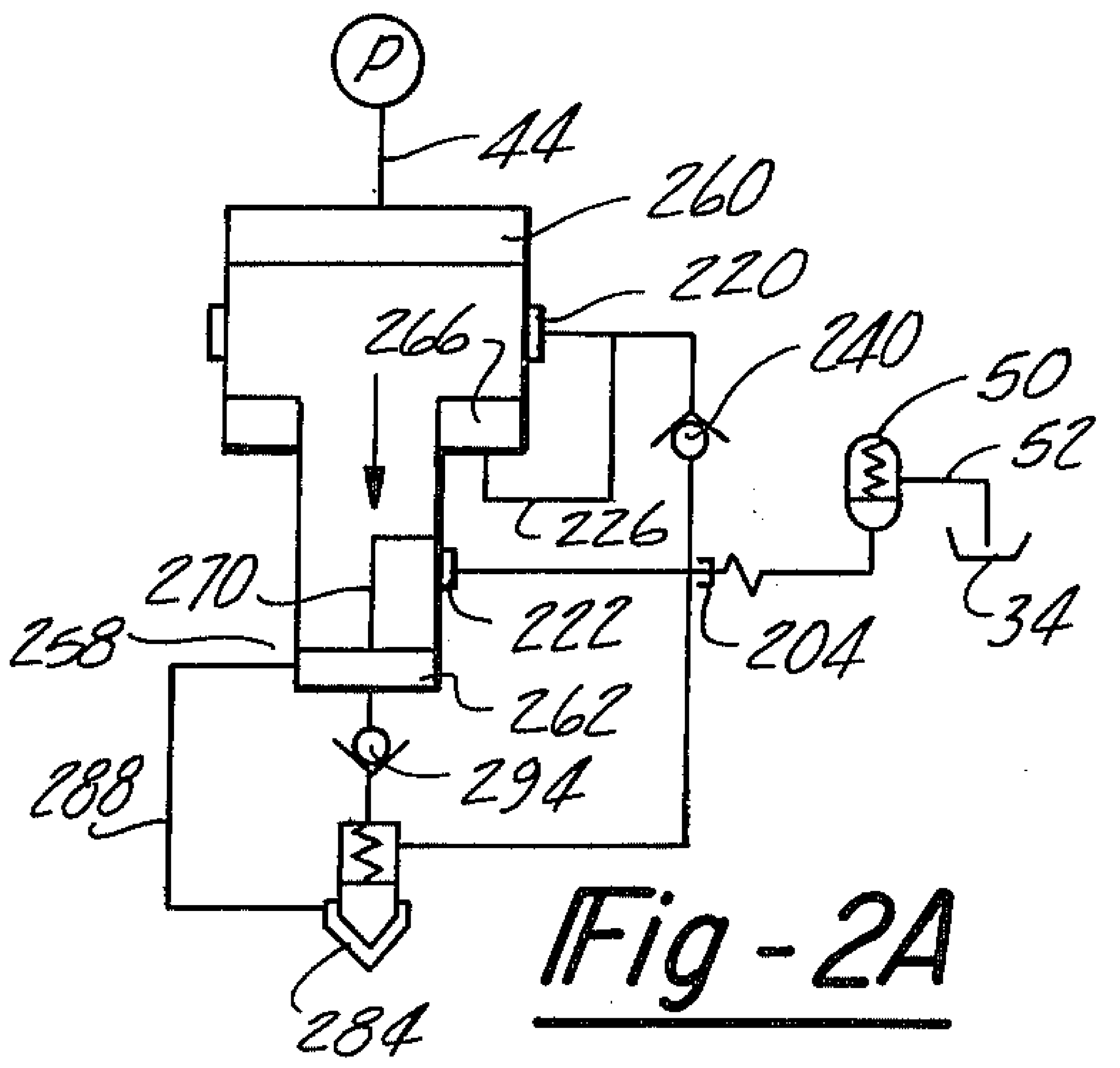

Fig-2A

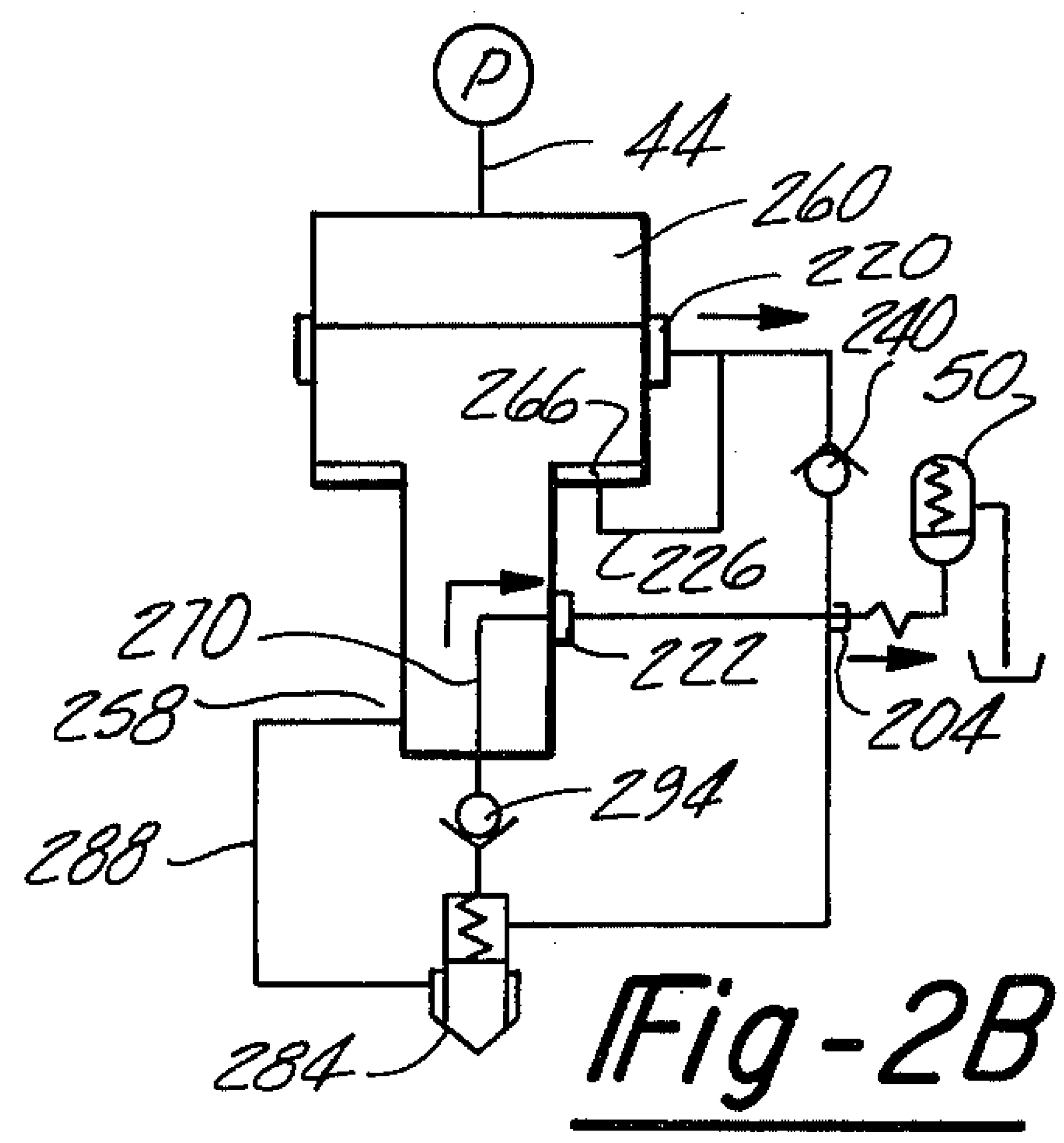

Fig-2B

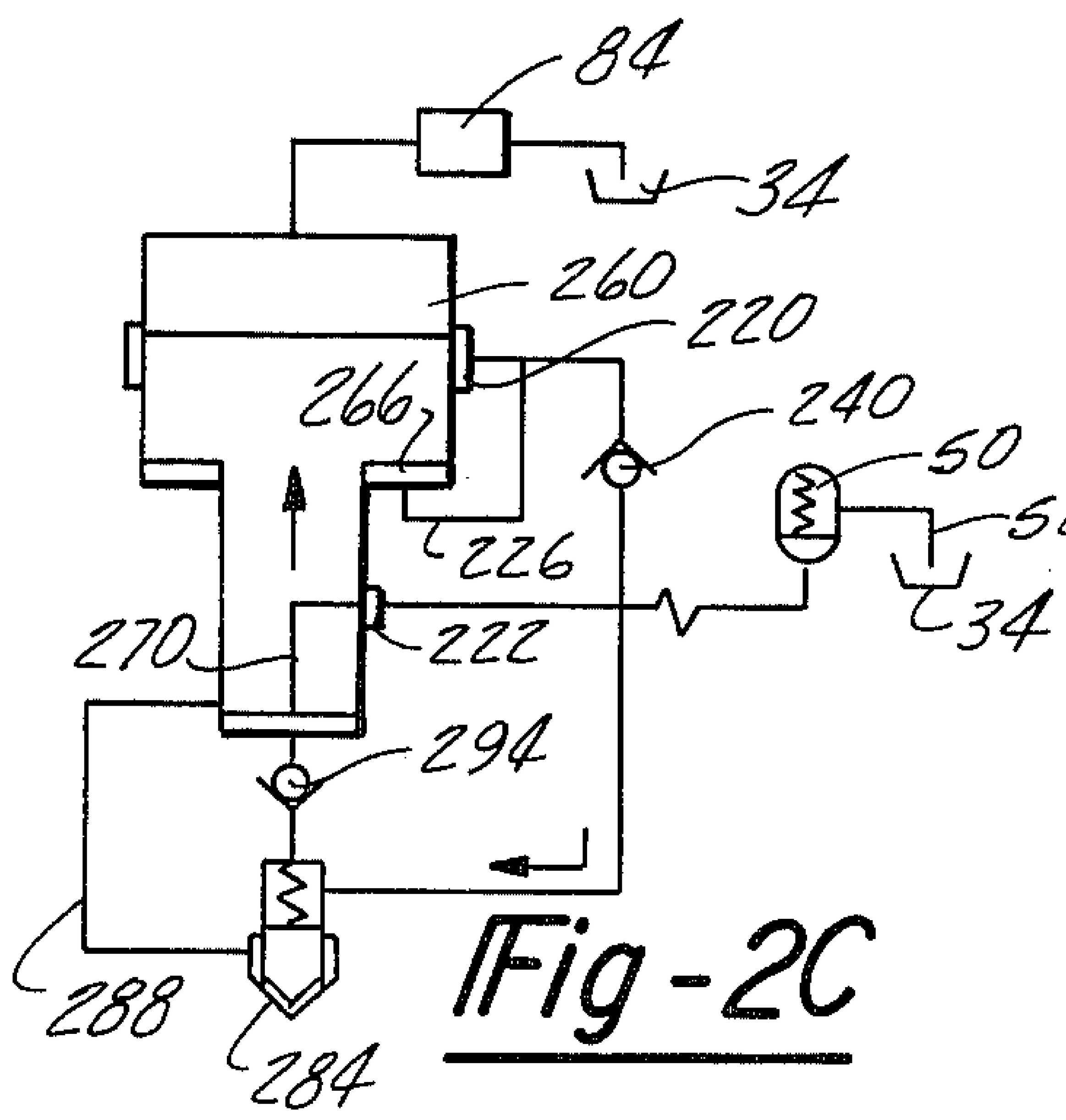

Fig-2C

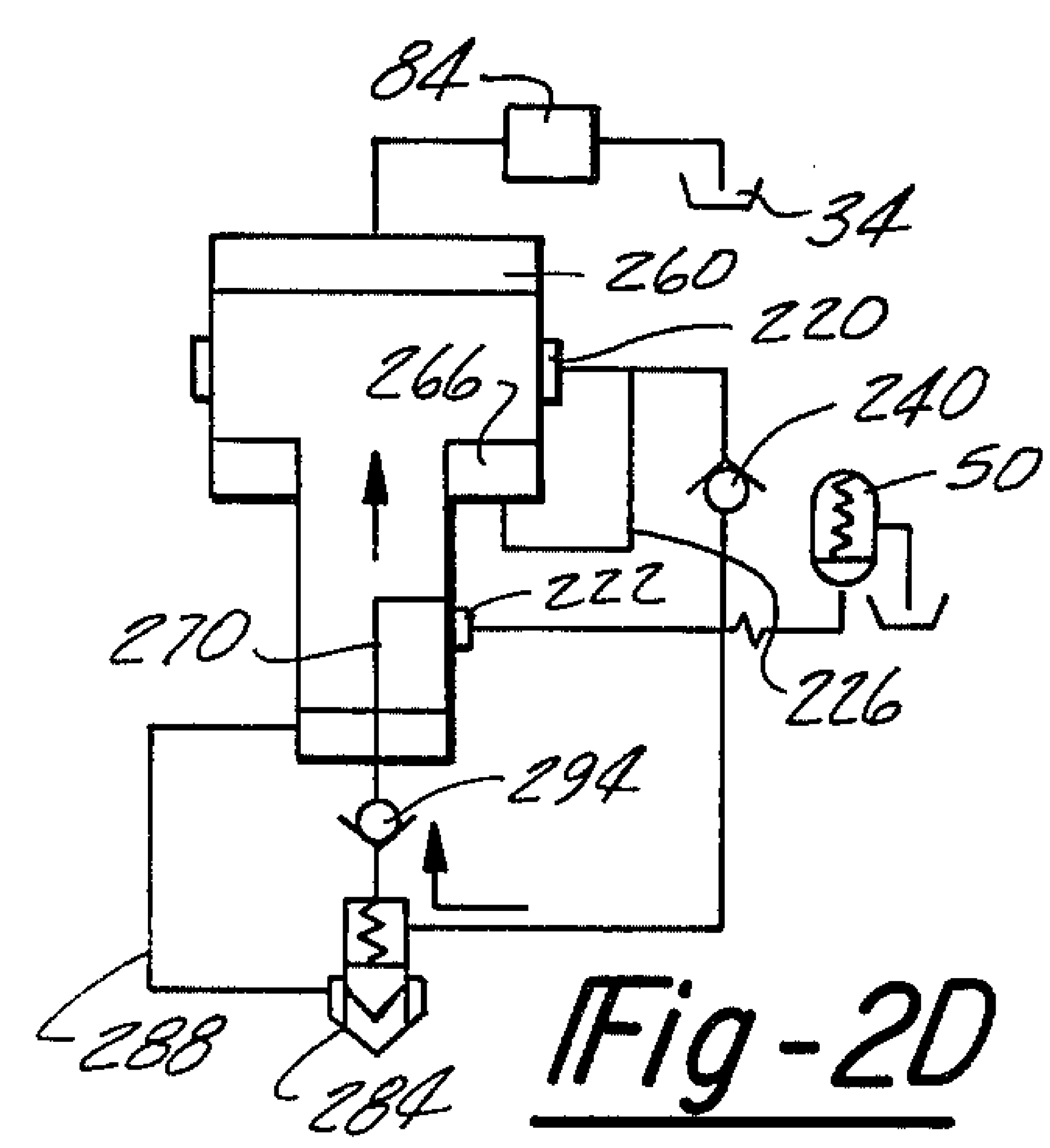

Fig-2D

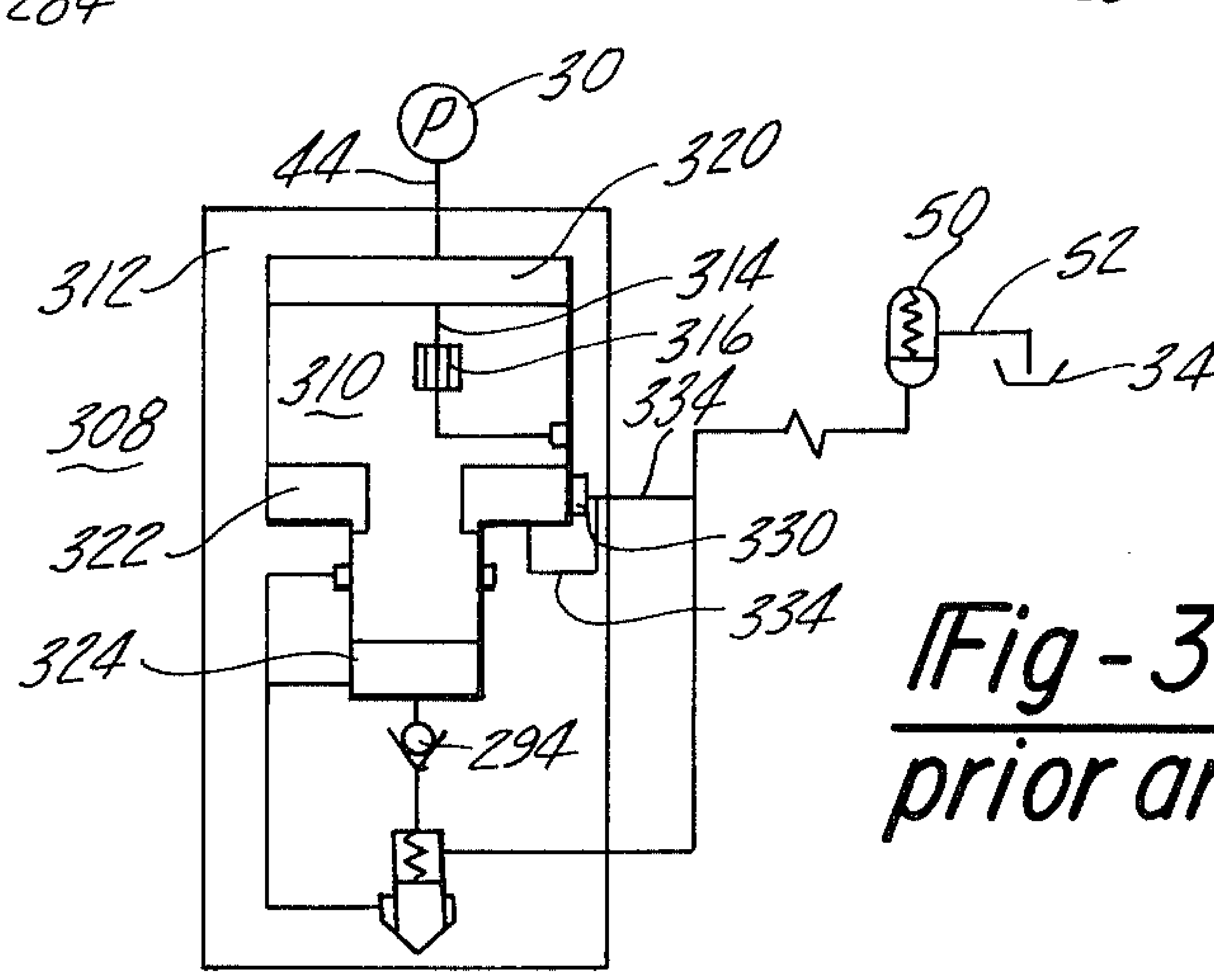

Fig-3
prior art

FUEL INJECTOR WITH INNER CHAMBER VACUUM

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to fuel injectors for .diesel engines and more particularly to a fuel injector having a metering and an injection mode of operation and an intensifier piston which defines an upper chamber, a middle chamber and a metering chambering wherein the motion of the piston cooperates to selectively maintain a vacuum or low pressure level within the middle chamber.

Diesel fuel injection systems often require that the fuel to be injected into the respective cylinders of the diesel engine be at pressures that may be in excess of 15,000 psi. Fuel systems which pressurize the fuel carrying components, upstream of the injector, at high pressure levels exhibit fuel leakage and engine horsepower drain. It is known that by utilizing injectors having an intensifier piston permits operation at lower upstream pressures. As an example, if it has been determined that the injection pressure of the fuel injector must be 18,000 psi, an intensifier piston having an intensification ratio of 3:1 would reduce the pump requirements from 18,000 to 6,000 psi. One such fuel system incorporating an intensifying piston is disclosed by Walter et al in the commonly assigned patent application U.S. Ser. No. 217,297, filed Dec. 17, 1980 now U.S. Pat. No. 4,426,977.

Broadly speaking, an intensifier piston includes a large face area upper body portion or member connected to a smaller face area lower body portion member. The intensifier piston is reciprocally situated, in form fitting contact, within a stepped bore of the injector housing. The geometry of the intensifier piston, as well as its reciprocating motion within the injector housing, define an upper chamber, proximate to and above the upper body portion. The upper chamber is adapted to receive pressurized fuel which is transmitted to a first pressure receiving surface of the upper member. The piston and housing also form a middle chamber that is situated between the upper portion and the large diameter portion of the stepped bore. A metering chamber is situated below a second pressure receiving surface on the lower body portion of the intensifier piston. During the operation of this type of injector, pressurized fuel is transmitted to the upper receiving surface of the intensifier piston, because of the relationship of the areas of the first and second pressure receiving surfaces, the intensifier piston inherently performs a pressure amplification function. The theoretical value of the intensification ratio is determined by the ratio of the areas of the first and second pressure receiving surfaces. As will be discussed below, the effective intensification ratio of these injectors is often less than the theoretical ratio.

Walter et al in U.S. Ser. No. 217,297, further incorporates a laminar flow restrictor situated in a piston. The purpose of this restrictor is to restrict the fluid flow from a downstream accumulator back into the upper chamber. The restrictor also permits the piston to move upward as the pressure above the piston is reduced due to the operation of a cooperating fuel pump.

It has been found that the injector of Walter et al and similar injectors display an injection pressure which is less than expected. The reduction of the injection pressure arises because of inefficiencies in its operation due to the additional work necessary to compress fuel within the middle chamber and also because of the additional work lost by pumping fluid through long lines between the injector and the fuel tank. This work generates unwanted heat within the fuel injector and drains needed horsepower from the engine.

These deficiencies are solved by the present invention by trapping a small amount of fuel under the primary or upper body member or portion of the intensifier piston so that as the intensifier piston rises during its metering mode of operation, the fluid pressure within the metering chamber is dropped to its vapor pressure. Consequently, during a subsequent injection mode of operation, there is no fliud to be pumped out of this chamber or to be compressed and therefore, no unnecessary work is expended. The invention further utilizes a check valve which prevents unwanted fluid from entering the middle chamber. The check valve further serves to restrict the flow of fuel from an accumulator into the upper chamber thereby creating a pressure differential across so that the metering mode of operation can start promptly.

More specifically, the fuel injector comprises a housing having a first port that is adapted to receive pressurized fuel from a first pressure source and a second port which is similarly adapted to be connected to a second source of pressurized fuel which is generally maintained at a pressure level less than the pressure level of the first source. The housing further includes a stepped bore having a larger first bore that is linked to a narrower second bore. The housing additionally includes a first dump port situated on the first bore and a second dump port that is situated on the second bore. An intensifier piston that is responsive to the pressure differential thereacross is provided for reciprocatively moving within the stepped bore and for selectively uncovering the first and the second port. The intensifier piston and the stepped bore cooperate to provide a plurality of variable volume chambers such as an upper or primary chamber, a middle or an inner chamber and a lower or metering chamber. The injector further includes a nozzle which extends from the housing and is operatively connected in fluid communication with the lower or metering chamber for injecting a predetermined quantity of fuel therefrom in correspondence with a motion of the intensifier piston. The fuel injector further includes a first fuel passage which connects the second port with the lower chamber having positioned therein a first check valve to inhibit the flow of fuel from the lower chamber through to the second port. The injector additionally contains a second fuel passage which connects the middle chamber to the second dump port and a third fuel passage having lodged therein a second check valve for inhibiting the flow between the second port and the first port. In addition, the fuel injector housing further includes a fourth fuel passage for connecting the first port to the middle chamber.

It is an object of the present invention to improve the efficiency of operation of diesel fuel injectors having intensifier pistons. It is a further object of the present invention to provide a fuel injector having a middle chamber that is selectively maintained at a low or vacuum pressure. It is a further object of the present invention to provide a fuel injector of simple construction and one that does not require sophisticated manufacturing operations.

It is a further object of the present invention to provide a diesel fuel injector having an effective intensification ratio which approximates the theoretical intensification ratio. A further object of the present invention is to provide a fuel injector having an injection and metering mode of operation which is characterized by a rapid transition between the modes of operation.

A feature of the present invention is the creation of a vacuum pressure within the inner or middle chamber. This vacuum pressure is not formed until the metering mode of operation has begun. More specifically, a small amount of fuel is trapped within the middle chamber during the injection mode of operation. During the metering mode of operation, that is, when the piston is caused to rise, the fluid pressure within this chamber is dropped to its vapor pressure. Consequently, during subsequent injection modes of operation, that is, when the intensifier piston is moving downward, no work can be expended in compressing fluid or in pumping fluid out of the middle chamber and therefore, no unwanted pressure forces are developed which tend to reduce the intensification ratio.

An advantage of the present invention is that it may be packaged and adapted to all sizes of diesel engines with virtually no engine modification. By increasing the efficiency of operation of the injector, the size and the flow capacity of cooperating distributor pumps, which supply fuel to each of the injectors, is correspondingly reduced.

According to the specific embodiment illustrated in the drawings of this application and discussed in detail below, the present invention comprises:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a hydraulic schematic diagram of a fuel delivery system incorporating features of the present invention.

FIGS. 2A, 2B, 2C and 2D are hydraulic schematic diagrams illustrating the modes of operation of a diesel fuel injector incorporating the present invention.

FIG. 3 illustrates a prior art diesel fuel injector.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIG. **1** which illustrates a detailed hydraulic schematic diagram of an electrically controlled fuel system for diesel engines. More specifically, there is shown a dual solenoid distributor pump **30** that is driven by the diesel engine (not shown). One such pump is disclosed by Walter et al in the commonly assigned patent application U.S. Ser. No. 217,297, filed Dec. 17, 1980 and is expressly incorporated by reference. The distributor pump **30** is connected to a liquid reservoir such as the fuel tank **34** through a fuel filter **36.** Fuel is received at an input port **38.** The distributor pump **30** is further adapted to communicate with a plurality of injectors **40***a–f* through output ports **42***a–f.* Each injector **40** includes a housing **200** that is adapted to connect with and receive fuel through one of the bi-directional injection lines **44***a–f* through a bi-directional first port **202.** Each injector housing further has a bi-directional second port **204** which is adapted to connect to another source of pressurized fuel. In particular, the second port **204** is connected to a low pressure accumulator **50** through the accumulator or pressure lines **46***a–f* and a common line or manifold **48.** The manifold **48** is connected to the accumulator and a relief valve **50** through a laminar flow restrictor **54** for each injector. The output of the accumulator **50** is connected via the pressure return line **52** to the reservoir or fuel tank **34.**

Inasmuch as the fuel injection system may be configured with any number of fuel injectors, it is necessary to distribute the output of the injection pump **30** to the appropriate injectors **40***a–f.* This is accomplished by utilizing the distributor valve **60.** The distributor valve comprises two distribution slots **62** and **64** which are selectively placed into communication with a plurality of openings **66***a–f.* The openings are maintained in fluid communication with the respective output portions **42***a–f* of the distributor pump. Further, details of the pump **30** are discussed in U.S. Ser. No. 217,297. Other major components of the distribution pump are a transfer pump **70** which is used to feed an injection pump **72.** The output of the injection pump is directed to the distribution valve **60** which selectively pressurizes the fuel injections **40***a–f* in time sequence with the combustion process within the engine in correspondence with the opening and closing of the timing valve **80** which is controlled by the electronic control unit, ECU **82.** The pump **30** fluid includes a metering valve **84** which is controlled by the ECU **82** which periodically connects the distribution valve **60** to the fuel reservoir **34.**

To initiate fuel injection, the timing valve **80** is closed in response to timing signals generated by the ECU **82** and the total output of the injection pump is diverted through the distribution slot **62** and in a specific fuel injector **40.** After the timing valve is closed, the fluid in the distribution slot **62** to a particular injection line **44,** is compressed by the action of the injection pump and a pressure pulse is transmitted down the injection line **44** thereby activating the particular injector and causing a determinable quantity of fuel that was previously stored or premetered in its metering chamber to be injected into the engine.

Reference is again made to the distribution slot **64** of the distributor valve **60.** The distribution slot **64** is situated relative to the distribution slot **62** such that it leads the motion of the distribution slot **62.** This is necessary since, as mentioned above, a quantity of fuel must first be placed or pre-metered into a particular injector **40** prior to the time that a pressure pulse is developed by the injection pump **72** due to the closing of the timing valve **80.**

To initiate the metering mode operation, the metering valve **84,** which is normally closed, is opened, in response to signals generated by the ECU **82,** thus connecting a specific injection line **44***a–f* to the fuel reservoir to relieve the pressure within that specific injection line.

Reference is now made to the hydraulic schematic diagram of a typical injector which is shown in the lower left-hand portion of FIG. **1.** Inasmuch as the communication and operation of the distributor pump **30** with respect to each of the fuel injectors **40***a–f* is identical, the following description is directed to the interrelationship between the distributor pump and the fuel injector **40***a.* In addition, where appropriate, the letters designating the plurality of injectors, i.e., letters *a–f,* will not be included in the following discussion. Each injector **40** comprises a housing **200** that is adapted to receive pressurized fuel from a first source such as the pump **30.** This pressurized fuel is received at the input or first port **202.** In addition, each injector is further adapted to receive pressurized fuel from a second source of pressure at the second input port **204.** The housing **200** includes a stepped bore **206** having received therein a intensified piston **250**. The bore **206** and piston **250** cooperate to define an upper, middle and lower variable volume chambers **260**, **266** and **262**, respectively. The stepped bore comprises an upper first bore **208** and a lower narrower second bore **210**. The housing further includes a first dump **220** port fabricated within the walls of the upper bore **208**. A second dump port **222** is fabricated within the walls of the seocnd or lower bore **210** passage. A fluid passage **226** connects the middle chamber **266** to the first dump port **220**. In the preferred embodiment of the invention, the first dump port **220** may comprise an annular cut-out circumscribing the walls of the upper or first bore **208**. The first dump port **220** is connected to the fluid passages **232** having inserted therein a check valve **240** which is connected such that fluid flow from the second port **204** through to the first dump port **220** is restricted. The second dump **222** is also connected to the second port **204** through the fluid passage **236** and **234**.

The intensifier piston **250** is tightly and reciprocatively received within the stepped bore **206**. The intensifier piston **250** includes an upper member of portion **252** that may be integrally formed with a lower narrower member **254**. The upper member **252** contains a pressure receiving surface **256**. The lower member **254** contains another pressure receiving surface **258**. As previously mentioned, the intensifier piston in cooperation with the stepped bore **206**, cooperates to provide a number of variable volume chambers such as the upper or primary chamber **260**, the lower or metering chamber **262**, and the middle or inner chamber **266**. The intensifier piston **250** further includes a fluid passage **270** having one end which intersects the pressure receiving surface **258** and another end which terminates at a wall of the lower member **254**. The termination of the fluid passage **270** at the wall of the lower member **254** is so configured as to connect the lower or metering chamber **262** to the dump port **222** when the intensifier piston **250** moves downward by a determinable amount. The dimensions of the upper member **252** are such that the upper pressure receiving surface **256** of the intensifier piston **250** will uncover a portion of the dump port **220** at a determinable amount of downward travel of the intensifier piston thus communicating the upper chamber **260** to the port **220**.

The injector **40** further includes a nozzle means **280** having a plunger **282** that is reciprocatively situated relative to the orifice(s) **284** and which is nominally biased to close the orifices **284** by a biasing spring **286**. The nozzle means **280** is connected to the lower chamber **262** by a fluid passage **288**. The biasing spring **286** is situated within a fluid receiving chamber **290**. The fluid receiving chamber **290** is connected to the port **204** via the fluid passage **292** and to the lower chamber through the check valve **294** which is connected to inhibit the flow from the lower chamber **262** into the fluid receiving chamber **290**.

The operation of the fuel injection system is discussed in greater detail below with the aid of FIG. **2**. The distributor pump **30** and more specifically, the transfer pump **70** and the injection pump **72** are driven by the engine. The transfer pump extracts fluid from the fluid reservoir or fuel tank **34**. The output pressure of the transfer pump **70** is maintained at a relatively low pressure such as 200 psi. After the injection pump **72** is filled, excess fluid is returned to the reservoir **34**.

The timing valve **80** during non-injection mode periods is normally maintained in an open position during which time the distribution slot **62** is maintained at the output pressure of the injector pump **72**. During this time, one of the lines **44** and the upper chamber **260** of a particular injector **40** is also maintained at the output pressure of the injection pump. It should be recalled that the distribution valve **60** connects the injection pump **72** to only one of the injectors **40***a–f* at any time. In response to a timing signal generated by the ECU **82**, the timing valve **80** is commanded to close. Upon the closing of the timing valve a pressure wave is generated and transmitted via one of the injection lines **44** such as **44***a* to an injector such as **40***a* which as illustrated in FIG. **1** is presently connected to the distribution slot **62** through opening **66***a*.

As mentioned, the pressure within the fluid passages and pressure lines connected to the injection pump **72**, during the intervals of time when the timing valve **80** is open, will approximately be maintained at a pressure which is not sufficient to crack open the nozzle **280**. However, upon the closing of the timing valve and the generation of the pressure wave, the pressure applied to a specific fuel injector may be 2,000–6,000 psi or higher. In response to this increased pressure of fluid within the upper chamber **260**, the intensifier piston **250** is caused to move downward. FIG. **2***a* illustrates the piston **250** of a particular injector **40** moving downward in response to the pressure wave created by the operation of the pump **30**. As illustrated therein, the walls of the intensifier piston **250** have closed off the dump ports **220** and **222**. The fluid that has been pre-metered, during a prior metering event, into the lower or metering chamber **262** is now compressed by the piston **250** to a pressure significantly higher than the pressure of the fluid in the upper chamber **260**. This increase in pressure is a direct result of the intensification ratio of the piston **250** resulting from the relationship in areas of the pressure receiving surfaces **256** and **258**. Fluid at this substantially higher pressure (7,500–18,000 psi) is caused to flow through the fluid passage **288** to the orifices **284** of the nozzle **280**. At some predetermined pressure the nozzle **280** will open permitting fuel or fluid to be injected into a specific cylinder of the diesel engine in timed relation to the combustion process therein. The piston **250** will continue its downward motion and injection will continue until the motion of the lower member **254** places the fluid passage **270** in communication with the dump port **222**. This opening of the dump port **222** permits the high pressure fuel within the metering chamber **262** and in the fluid passage **288** to be rapidly dumped through the port **222** to the accumulator **50** thus causing the pressure within the metering chamber **262** to drop therein enhancing the rapid termination of injection. This relationship is shown in FIG. **2***b*.

At this point in time the injection mode of operation is virtually completed and flow from the pump **30** is no longer required. The motion of piston **250** places the pressure receiving surface **256** in communication with the dump port **220** thereby connecting the upper chamber **260** to the low pressure accumulator **50**. This action relieves the pressure in the upper chamber **260**. The flow of excess fluid from the pump **30** through port **204** fills the accumulator **50** to provide a source of fuel to later be pre-metered to other injectors during their respective metering modes of operation. It should be appreciated that after each injection mode or event the pressure within the upper chamber **260** and its corresponding injection lines *44a–f* will temporarily stabilize at the pressure determined by the accumulator **50**. It should also be noted that the dumping of the pressure within the metering chamber **262** and the upper chamber **260** may be performed sequentially or simultaneously.

Upon termination of an injection event, the piston **250** will be positioned at the bottom of its stroke as illustrated in FIG. *2b* with its respective injection line **44** connected to the low pressure manifold **48** and accumulator **50** via the dump port **220**. The piston will remain in this position until the next metering interval.

In addition, fuel is permitted to flow from the middle chamber **266** through fluid passage **226** and to the dump port **220**, thus allowing any fuel that may have leaked into the middle chamber to be dumped. This condition is also illustrated in FIG. *2b*.

Prior to each injection event, each injector *40a–f* must be charged or pre-metered with a specific quantity of fuel. In response to an electrical signal generated by the ECU **82**, the metering valve **84** is activated and a particular injector is connected to the metering valve **84** through one of the openings *66a–f* in the distributor valve **60**. More specifically, a pulse width metering signal is generated by the ECU **82** in correspondence with the passage of the metering slot **64** across a specific one of the openings *66a–f* within the distributor valve **60**.

As previously mentioned, each metering event or interval is begun by opening the metering valve **84** in response to the activation signals received from the ECU **82** and ends when the metering valve is closed. The advantage of utilizing a separate valve for metering and another valve for timing permits the metering event to occur separately from that of injection thus isolating the two events. The isolation of these functions permits a greater time to meter fuel into a specific fuel injector **40** and improves the overall accuracy of the fuel metering. When the metering valve **84** is opened, the fluid near the metering valve flows through the valve causing a pressure drop in a particular line **44**. As this pressure drop is transmitted down a line **44**, the pressure will drop in chamber **260**. The pressure below the intensifier piston in chamber **262** is set by the accumulator **50**. The pressure within chamber **260** will be less than the pressure in chamber **262**. This pressure differential will cause the piston to move upward. As the piston moves upward, fluid from the accumulator **50** flows into the metering chamber **262** through lines **234, 292** and through the metering check valve **294**. Fluid will continue to enter the metering chamber **262** until the metering valve **84** is commanded to close; this would correspond to the removal of the activation signals transmitted from the ECU **82**. FIG. *2c* illustrates the beginning of the metering mode of operation with the piston moving upward.

It can be seen that by knowning the pressure differential of the accumulator **50** and of the fuel tank **34** and the restrictions imposed by the metering valve **170**, the orifice **174** and the injection lines **44**, then the flow rate of fuel out of the upper chamber **260** and also the flow into the metering chamber **262** can be determined. Consequently, by monitoring the time that the metering valve is open, the quantity of fuel permitted to flow into the metering chamber **262** can be controlled.

As the piston **250** moves upward, as illustrated in FIG. *2d*, due to the filling or pre-metering of fuel to the metering chamber **262**, the fluid passage **270** is moved out of communication with the dump port **222** thus terminating communication between the metering chamber **262** and dump port **222**. In addition, as the piston moves upward, the upper pressure receiving surface **256** is moved out of communication with the dump port **220** therein trapping a quantity of fuel within the inner or middle chamber **266**. As the piston continues to rise during the metering event, the fluid pressure of the fuel trapped within the middle chamber **266** is reduced to its vapor pressure. The metering as described is made possible by using the vacuum check valve **240**. The check valve **240** is required to ensure that the fluid from the accumulator flows to the metering chamber **262** through the metering check valve **294**. Without the vacuum check valve **240**, there will be a direct short circuit around the intensifier piston **250** from port **204** to line **44**. This short circuit would not force the piston **250** upward to start metering fluid into chamber **262**.

The second purpose of the vacuum check valve **240** is to prevent fluid flow from the accumulator **50** from flowing to the middle chamber **266** so that vapor pressure will be formed in this chamber to increase the effective intensifier ratio during injection as described elsewhere.

It should be appreciated that during subsequent injection modes of operation, work must be expended in compressing the fuel with the metering chamber **262**. However, as in prior art injectors, if fuel resides within the middle chamber unnecessary work must also be expended to compress the fluid. This unnecessary work is eliminated and the efficiency of the present fuel injector greatly increased by creating within the middle chamber, the reduced or vacuum pressure level.

After the metering event is completed, the distributor valve will connect the injection pump **72** to another injector **40** such as injector **40*b*** which has just received its metered quantity of fuel and will initiate another injection event or interval in a manner identical to that described above.

Reference is now made to FIG. **3** which illustrates a prior art fuel injector **300** having an intensifier piston **310** situated within an injector housing **312**. The intensifier piston includes a fluid passage **314** and a laminar flow restrictor **316** inserted therein. The motion of the piston **310** and housing **312** corporate to form three variable volume chambers. More specifically, an upper chamber **320**, a middle chamber **322** and a lower or metering chamber **324**. In addition to other fluid passages, a nozzle and check valve, the housing further includes a dump port **330** which is connected to the middle chamber **322** and to an accumulator **50**.

The operation of fuel injector **300** is similar to the operation of the present invention. The piston **310** will begin to move downward due to the generation of pressure wave by the distributor pump **30**. At some point and time, the fluid passage **314** will communicate with dump port **330**, thus relieving the pressure within the upper chamber **320** by connecting the upper chamber **320** to the lower pressure accumulator **50**. It can be appreciated that with the injector in its lower position, fuel will flow from the upper chamber the accumulator **50** through the dump port **330**.

During the metering mode, that is when the pressure in the upper chamber **320** is reduced to a level below that of the pressure level established by the accumulator **50**, the intensifier piston **310** will move upward. The laminar restrictor **316** is required to prevent the flow from the accumulator **50** from not flowing directly into line **44**, and to flow through the metering check valve **294** into chamber **324**. As the piston **310** moves upward, fluid from the accumulator **50** will continue to flow into the middle chamber **322** through line **334**.

During a subsequent injection mode of operation, i.e., when the piston **310** is caused to move downward due to the increased pressure generated in the upper chamber **320**, the piston must of course compress the fluid within the metering chamber **320** to initiate injection. However, the piston must also compress and overcome the reactive forces due to the fuel within the middle chamber **322** which must be forced out of the middle chamber through line **334**. The work expended to compress and to force the fluid out of the middle chamber **322** is a direct cause of the inefficiencies present in this prior art fuel injector and is overcome as previously indicated by the present invention. In addition, the laminar restrictor **314** which is generally an expensive item is replaced in the present invention by an inexpensive check valve **240** which serves the dual purpose of creating the vapor pressure in the middle chamber **266** as well as having metering start promptly by eliminating the short between lines **204** and **44**.

Many changes and modifications in the abovedescribed embodiment to the invention can, of course, be carried out without departing from the scope thereof. Accordingly, that scope is intended to be limited only by the scope of the appended claims.

Having thus described the invention, what is claimed is:

1. A fuel injector having metering and injection modes of operation and adapted to receive fuel from a first and a second source of pressurized fuel for injecting a pre-metered quantity of fuel into a diesel engine comprising:

a housing having a first port adapted to communicate with the first pressure source and a second port adapted to communicate with the second pressure source;

intensifier piston means reciprocatively received within said housing for defining an upper, a middle and a lower variable volume chamber therebetween; and

means for permitting a predetermined first quantity of fuel to be received within said middle chamber during the injection mode of operation, and for reducing thereafter the pressure level of said first quantity of fuel within said middle chamber to a first pressure level and for pressurizing said first quantity of fuel during said injection mode of operation.

2. The fuel injector as defined in claim **1** wherein said first pressure level corresponds to the vapor pressure level of said first quantity of fuel.

3. A fuel injector having metering and injection modes of operation comprising:

a housing adapted to receive fuel at a determinable first pressure level at a bi-directional first inlet port and further adapted to receive fuel at another pressure level at a bi-directional second inlet port;

intensifier piston means, having a first pressure receiving surface exposed to fuel at said first pressure level and a second pressure receiving surface exposed to fuel at said another pressure level, for reciprocatively moving within said housing in response to the pressure differential thereacross, and for establishing, in cooperation with said housing variable volume chambers including an upper chamber, connected to said first inlet port, and situated above said first pressure receiving surface, a lower chamber connected to said second inlet port and situated below said second pressure receiving surface and a middle chamber situated therebetween, and for compressing the fuel within said lower chamber at a pressure determined by the ratio of the areas of said first and said second pressure receiving surfaces;

first means for establishing a determinable level of vacuum fuel pressure within said middle chamber during the metering mode of operation in correspondence with the motion of said intensifier means; and

nozzle means in fluid communication with said lower chamber, for injecting fuel therefrom in correspondence with the motion of said intensifier piston means during the injection mode of operation.

4. The fuel injector as defined in claim **3** wherein said first means includes means for introducing a determinable quantity of fuel into said middle chamber prior to the beginning of the metering mode and includes means for expanding the volume of said middle chamber during said metering mode to reduce the pressure therein to the vapor prssure of the fuel.

5. The fuel injector as defined in claim **4** wherein said means for expanding includes said second receiving surface.

6. The fuel injector as defined in claim **5** wherein said first means further includes a first passage for selectively communicating said upper chamber to said middle chamber in correspondence with the motion of said intensifier means.

7. The fuel injector as defined in claim **6** further including:

second means for communicating said upper chamber to said second inlet port in correspondence with the motion of said intensifier means.

8. The fuel injector as defined in claim **7** wherein said second means includes a second passage, having a check valve lodged therein for starting metering promptly.

9. The fuel injector as defined in claim **8** wherein said check valve inhibits flow to said middle chamber for creating a vacuum in said middle chamber.

10. The fuel injector as defined in claim **7** further including third means connected to said second inlet port for relieving the pressure within said lower chamber to terminate the injection mode of operation, in correspondence with the motion of said intensifier means.

11. The fuel injector as defined in claim **10** wherein said third means includes a fuel passage situated within said housing and another fuel passage located within said intensifier means having one end in fluid communication with said lower chamber and having another end that is selectively brought into fluid communication with said fuel passage in correspondence with the motion of said intensifier piston means.

12. A fuel injector comprising:

a housing having a first port that is adapted to receive pressurized fuel from a first source, a second port adapted to be connected to a source of fuel pressurized at a pressure level less than the level of said first source and a stepped bore having a larger first bore linked to a narrower second bore, said housing further including a first dump port situated on said first bore, a second dump port situated on said second bore;

intensifier piston means responsive to the pressure differential thereacross for reciprocatively moving within said stepped bore, and for selectively uncovering said first dump port and said second dump port, said intensifier piston means and said stepped bore cooperating to provide a variable volume upper or primary chamber, in communication with said first port middle or inner chamber and lower or metering chamber in communication with said second port;

nozzle means, extending from said housing and operatively connected, in fluid communication, to said lower chamber, for injecting fuel therefrom in correspondence with the motion of said intensifier piston means;

first fuel passage means for connecting said second input port with said lower chamber including first check valve means for inhibiting flow of fuel from the lower chamber to said second port;

second fuel passage means for connecting said first dump port to said middle chamber;

third fuel passage means for connecting said first dump port to said second port including second check valve means for inhibiting the flow between said second port and said first dump port and said middle chamber;

and

forth fuel passage means for connecting said second dump port to said second port.

13. The fuel injector as defined in claim **12** wherein said intensifier piston means comprises:

an upper cylindrical member, having a first pressure receiving surface thereon, forming the lower extreme of said upper chamber, said upper cylindrical member attached to a lower cylindrical member, forming the upper extreme of said lower chamber, said intensifier piston means further including passage means for connecting said second dump port to said lower chamber in correspondence with the motion of said intensifier piston means within said stepped bore.

14. The fuel injector as defined in claim **13** wherein said first and said second check valve means are check valves.

15. The fuel injector as defined in claim **14** wherein said nozzle means includes orifice means for permitting outflow of fuel therefrom and plunger means for selectively opening and closing said orifice means in correspondence with the fuel pressure in said metering chamber.

16. In a fuel injector having metering and injection modes of operation and adapted to receive fuel from a first source of pressurized fuel and from a second source of pressurized fuel through a flow restrictor for injecting a pre-metered quantity of fuel into a diesel engine wherein the fuel injector includes: a housing having a first port adapted to communicate with the first pressure source and a second port adapted to communicate with the second pressure source; and an intensifier piston means reciprocatively received within said housing for defining an upper, a middle and a metering variable volume chamber therebetween;

a method comprising the steps of:

permitting a determinable amount of fuel to be received within the middle chamber during the injection mode of operation;

reducing the pressure of the received quantity of fuel in the middle chamber, during the metering mode of operation;

introducing a determinable quantity of fuel into the metering chamber during the metering mode of operation;

pressurizing the upper chamber, during the injection mode of operation to cause the intensifier piston to compress the fluid within the metering chamber; and

ejecting fuel from the metering chamber.

17. The method as defined in claim **16** wherein said step of reducing includes reducing the pressure of the received quantity of fuel to its vapor pressure.

18. The method as defined in claims **16** and **17** wherein the step of ejecting is performed prior to or at the time that fuel vapor within the middle chamber is caused to return to a liquid state.

19. In a fuel injector having metering and injection modes of operation and adapted to receive fuel from a first source of pressurized fuel and from a second source of pressurized fuel through a flow restrictor for injecting a pre-metered quantity of fuel into a diesel engine a method comprising the steps of:

premetering a first determinable quantity of fuel into the metering chamber during a metering mode of operation;

compressing the fuel within the metering chamber during the injection mode to a pressure level sufficient to cause injection of fuel from the fuel injector;

causing a second determinable quantity of fuel to enter the middle chamber, prior to the termination of the inspection mode of operation;

relieving the pressure above the intensifier piston to cause the intensifier piston to move upward and again permit the premetering of the determinable quantity of fuel to enter the metering chamber;

entrapping the second determinable quantity of fuel within the middle chamber; and

reducing the pressure level of the fuel within the middle chamber to its vacuum pressure prior to the next injection mode of operation creating a back pressure in the middle chamber.

20. The method as defined in claim **19** wherein the step of reducing includes increasing the volume of the middle chamber.

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